Evaluating Data Storytelling Strategies: A Case Study on Urban Changes

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***Abstract*—Understanding urban changes is important for both citizens and administrations from several perspectives, ranging from the monitoring of the territorial development in the long run, to the support to business decision making, and to the people involvement in the administration policy. Data storytelling plays a big role in explaining both the factors involved in this complex phenomena and the effects that administration choices have on the territory. This work aims to compare the communication power of different data storytelling strategies using "semantic" language (newspaper articles) and "perceptive" language (maps) in the context of urban changes. The study focuses on the cognitive strategies that human beings apply to process perceptive and semantic information. In particular, we compare the ability of two groups of users to understand and to recall information about the metamorphosis of the Italian city of Turin after the XX Olympic Winter Games competition in 2006. The same information about the city has been provided through infographics to the first group and through newspaper articles to the second one. Both users' groups have been observing the information support for the same interval of time. The fruition strategies of the users have been observed by means of an eye tracker device, while the comprehension of the information has been verified using a questionnaire. The experiments show that, within fixed time constraints, the users provided with infographics gain a deeper understanding and a better ability of recall the represented phenomenon then the others. Further results about the comparison of the view patterns on the different types of information support are documented.**

Keywords–Human Reasoning; Data Storytelling; Eye Tracking.

I. INTRODUCTION

In a global scenario, cities have become nodes in a world-wide network and this connection context has increased the attention they need to receive. Preserving and increasing the competitiveness and the attractiveness of cities is a challenge not only for local administrations but also for central governments [1]. Indeed, at the time of writing, we find in the first point of the USA President's agenda the creation of a White House Office on Urban Policy focused on the development of a strategy for the American metropolis for ensuring that all the resources allocated to urban areas are effectively spent on the highest-impact programs [2]. This is a measure to contrast poverty, to facilitate the economic integration of families and communities. However, to strike the goal, people need to know they are part of the project: they need to be updated about the progress of the strategy in action and how it affects the urban environment in a way they can easily understand. The territorial development can be observed by citizens through different information supports: reading newspaper articles, for examples, or exploring narrative visualizations such as interactive maps.

Data storytelling can play a big role in explaining the factors involved in this kind of complex phenomena, such as the metamorphosis of a city as the effect that administration choices have on the territory. Indeed, human beings have always used stories to convey information, because structuring facts into a narrative schema is an effective way to present their main features and to recall them, by making a point. In this context, information visualizations can be used to communicate in a story-like fashion, providing the readers with a narrative experience and, when properly arranged, piloting their attention and keeping them oriented across scene transitions [3] [4].

This work studies how human beings process the information conveyed by different data storytelling media. We compare strategies using respectively semantic language (newspaper articles) and perceptive language (maps) in the context of urban changes. In particular, we consider the regeneration process of the Italian city of Turin triggered by the XX Olympic Winter Games. That competition, indeed, has played the role of catalyst of an urban, social and economic renewal [5]. In this paper, we evaluate the ability of two groups of users to understand and to recall information about Turin's metamorphosis. The same information about the city has been provided through information visualizations to the first group and through two newspaper articles to the second one.

Subjects have been asked to answer to a questionnaire about the message they have extracted by the different supports. Moreover, in order to gain further insights about the information processing, their ocular movements and other statistics about their visual patterns [6] have been studied and compared thanks to an eye tracking device.

In the following, we present related work needed to place our research and experimental efforts in Section II. We delve into the details of our comparison procedure in Section III. Results analysis is provided in Section IV. Finally, we conclude and introduce future work in Section V.

II. RELATED WORK

Storytelling is one of the main players within the Information Visualization field, especially when considering

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information comprehension and recall issues [7]. Narrative visualizations help to turn information into knowledge that people use to understand phenomena and to make decisions. In particular, Data Storytelling exploits visualization features and structures belonging to traditional storytelling for conveying the information associated with digital data. By exploiting perception and visual sense it is then possible to improve the understanding and the recall of stories based on data representing complex phenomena. Indeed, stories provide the connecting fabric between facts to make them memorable [8]. A well-told story conveys great quantities of information in a format that is easy to assimilate.

Storytelling effectiveness has been exploited, analyzed and evaluated especially in the context of learning strategies. In particular, the cognitive results have been typically verified by supplying to the students a questionnaire or by interviewing them after the visualization of the information support [9] [10].

Eye tracking is an outstanding tool for studies related to visual search and visual perception. It allows for the recording of eye movements during the visualization of information supports and for the analysis of view patterns. It has been widely exploited for this kind of analysis on supports such as websites [11], videos [12], newspapers [13], maps [14] [15], and others. Furthermore, it is currently widely adopted in human-machine interface usability tests [16].

In this work, within the context of the evaluation of urban changes communication strategies, we couple the traditional methods for the informative power evaluation with the eye tracking analysis in order to gain deep insights, both qualitative and quantitative, about the cognitive features related to the fruition of two different kind of information supports in time-constrained conditions.

III. Experiment

In the following, we describe the experiment we run.

A. Participants

Twenty-eight participants have volunteered in the experiment. They are students at the University of Naples "Suor Orsola Benincasa" (16 girls and 12 boys). None of them have received money or course credit for their participation. Their age range is 20-23. All of them come from Naples and its surroundings and have normal or corrected to normal vision. Participants have been divided into two groups, Group 1 and Group 2, each of 14 subjects.

B. Materials

The two groups have been provided with information displayed in two different ways:

- Prototype 1: Infographic maps (*perceptive* information supports)
- Prototype 2: Articles (*semantic* information supports)

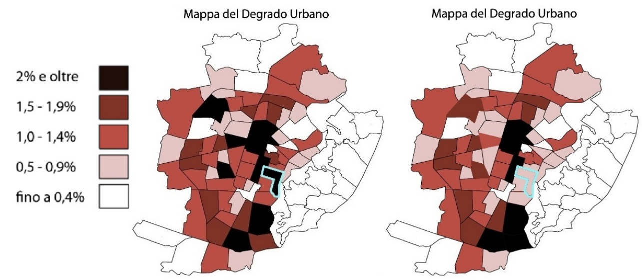

Figure 1. Prototype 1 supports

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HOME | NOTIZIE | DESTINAZIONI | WEEKEND | REPORTAGE | TOP TEN | MA

Articolo

Modifica ricerca — Ritorna alla precedente ricerca

Stampa — PDF — Invia ad un amico

Pubblicazione: 26-03-1994, STAMPA, TORINO, pag.33
Sezione: Cronaca di Torino
Autore:

Gli abitanti si riuniscono per organizzare la lotta a delinquenza e degrado.San Salvario in stato d'assedio.Ultimo episodio: macellaio blocca e lega rapinatore.Polizia al contrattacco: otto arresti per spaccio di droga.

Comincera' martedi' prossimo la primavera di SAN SALVARIO. Gli abitanti del quartiere si riuniscono nei locali della parrocchia per ribellarsi alla delinquenza. Ci saranno tutti: il piccolo commerciante, l'ambulante del mercato, l'inquilino della casa fatiscente, il vigile che solitamente piantona la sede vuota di via Ormea 45, simbolo del DEGRADO che si e' abbattuto sulla zona con la furia di un torrente in piena. Sul tavolo, i problemi di sempre e le soluzioni che non arrivano mai. I problemi si chiamano droga, abusivismo, illegalita', paura, senso di solitudine e di abbandono. E le soluzioni? Il consiglio di circoscrizione ha provato a elencarle in un ordine del giorno

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Articolo

Modifica ricerca — Ritorna alla precedente ricerca

Stampa — PDF — Invia ad un amico

Pubblicazione: 25-03-2010, STAMPA, TORINO, pag.76
Sezione:
Autore: ITALIANO PAOLA

I dati dello sportello della Circoscrizione: cittadini insoddisfatti solo del decoro urbano.Il quartiere si scopre sicuro.Calati spaccio e delinquenza.Le segnalazioni piu' numerose per le strade dissestate San Salvario.

PAOLA ITALIANO Il problema piu' grave di SAN SALVARIO? Le strade e i marciapiedi rotti. Sembra un altro quartiere quello che, fino a qualche anno a fa, era noto per l'alto tasso di microcriminalita', e dove il DEGRADO era legato soprattutto alla presenza di spacciatori e tossicodipendenti. A rivelarlo e' il quadro che emerge dai dati dello sportello criminalita' e qualita' della vita attivo sulla circoscrizione 8 relativi all'anno 2009. Il confronto con i dati del 2008 dice, innanzitutto, che le segnalazioni sono diminuite, anche se di poco: 120 contro le 134 dell'anno precedente. E rivelano che i cittadini si lamentano soprattutto della scarsa manutenzione

Figure 2. Prototype 2 supports

1) Prototype 1: Group 1 has been provided with two maps of the city of Turin showing different states of urban decay for each district by using colors (Figure 1). The level of urban decay is in the legend of the infographic with increasingly darker shades of color, starting from low urban decay (*white*) up to a high level of urban decay (*black*). One district among the others, the San Salvario one, has been highlighted in both the first and the second map, in order to make the viewer focus on the decay trend of that area in particular.

2) Prototype 2: The second group of participants (Group 2) has been provided with two articles from an Italian newspaper (web edition) about urban decay in the San Salvario district in 2002 and in 2010 (Figure 2). Article 1 describes the umpteenth fact of crime in a neighborhood characterized by degradation and drug smuggling. In particular, it refers to the fact that citizens are forced to fend for themselves, since the police is not able to stem the flow. Article 2 states that, according to the collected data, the quality of life in San Salvario district, known as a symbol of the drug dealing and crime, has improved a lot. Reports of citizens now concern normal maintenance of the roads. In both articles, two words have been highlighted: "urban decay", ("degrado" in Italian), because we wanted the participants to focus on the topic, and "San Salvario", which is the name of the district where the facts are set.

C. Procedure

Participants have been instructed to simply observe the pictures passing on the screen. The images have been showed for 15 seconds each and have been presented in different succession to avoid fatigue or list effects. After watching the slide show, participants have been asked to answer a short

questionnaire about what they had seen. In both cases, the questionnaire was made by four open questions.
The questionnaire in the case of Prototype 1 was:

- Question 1: Which city is represented in maps?
- Question 2: What phenomenon is described in the maps you've seen?
- Question 3: Is the observed phenomenon increased or decreased from the beginning to the end?
- Question 4: With respect to the area highlighted in light blue in the map, is the phenomenon increased or decreased?

The questionnaire in the case of Prototype 2 was:

- Question 1: In which city the facts described in the articles take place?
- Question 2: What kind of phenomenon is described in the articles?
- Question 3: Is the phenomenon increased or decreased from the first to the last article?
- Question 4: According to the articles, which area of the city is particularly struck by the phenomenon?

Answers to questions 2 and 3 are fundamental to compare the subjects' comprehension of the represented urban change. Question 1 and question 4 are exploratory questions that have been provided to the students in order to let the authors gain further knowledge. In particular, question 1 allows for the evaluation of the subjects' ability to geographically contextualize the phenomenon while question 4 concerns the cognitive impact of the selective highlighting used in both supports. The selective highlighting is a strategy adopted by the experiment designers for driving the viewer's attention on some specific parts of the supports in order to help him in the information extraction process. As already mentioned when describing the supports, the highlighted parts were the topic name and the district name in the articles and the San Salvario area in the maps.

During the experiment, eye tracking data have been collected. The Facelab 5.0 desktop eye tracking system [17] has been exploited to observe, record and objectively measure subjects' behavior in presence of both the information supports. Such system, developed by TEA Seeing Machines, consists of two cameras mounted on a stereo head and of an infrared (IR) pod. The IR pod emits infrared light, which is reflected off users' eyes; the reflection is recorded by the two cameras to track the eye movements. Unlike wearable eye trackers, the Facelab system is non-invasive, so that the subjects' behavior has not been affected by the presence of the tracking device. A software suite called Eyeworks from Eyetracking Inc. [18] has been used for data collection and analysis. In particular, we have exploited such tool to perform Area-of-Interest (AOI) analysis and to build useful data representations such as heat maps, gaze cluster visualizations, gaze fixation maps, and statistical charts.

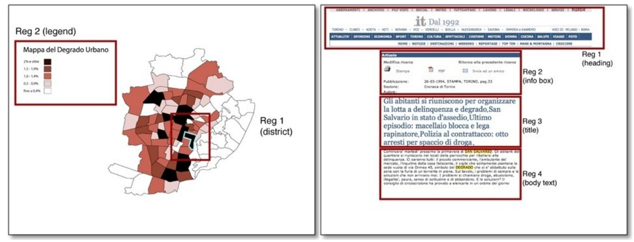

Figure 3. Areas of interest in Prototype 1 and Prototype 2

IV. Results

In order to generate statistics, it has been necessary to identify the AOIs, i.e., the relevant target regions to analyze. The heat map is a convenient method to aggregate results and gives an immediate impression of the AOIs watched by subjects. A color scale, moving from blue to red, indicates the duration of gazes. In Prototype 1, the AOIs are the legend and the district; in Prototype 2 the AOIs are the heading, the info box, the title and the body text (Figure 3).

A series of metrics have been selected to evaluate the participants' ocular behavior we have captured by means of the eye tracker. Particularly, we have focused on two aspects: fixations (FX) and gazes (GZ) [19] [6]. The more frequent the gaze, the more important the area: if a particular region on the screen attracts the user's attention, the number of gaze directed to that particular region is greater than that of any other region on the screen [20]. It is assumed that a big number of fixations on a particular region indicates a significant area of interest. Fixation duration (FD) is considered a measure of the visual complexity of an AOI: longer fixations indicate the difficulty of participants to extract information by a display area. Time to first Fixation (TF) is the time occurring between the start of the task and the first fixation on an AOI. This measure is informative about the scanning strategies adopted by participants [20].

We have analyzed and herein provide the Means (M) and the Standard Deviation (SD) for the measurements of the aforementioned metrics in the experiment results shown in Table I and Table III. Parametric tests (t-tests and F-tests) on dependent means were realized for each of the measures to compare the performances of participants in the different AOIs.

A. *Results for Prototype 1 (perceptive support)*

1) Heat map: Figure 4 represents a sample heat map we have obtained from the eye tracking analysis of the testers visualizing the Prototype 1 support. In the bottom-left part, the support is represented without the overlapping heat map in order to show that the most viewed region is exactly the one with the bold cyan borders, corresponding to the San Salvario district. Indeed, the red spots, over the legend and the highlighted district, indicate that the group of subjects have moved to these regions of interest for a significant period of time.

2) Gaze Observations in Each Region : Data on the number of gazes in each region in Table I reveal that all subjects have looked both regions ($t(13) = 1.44$, $p = .17$) and that the

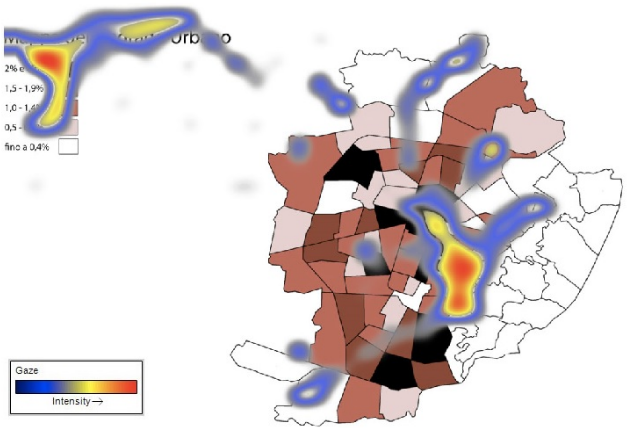

Figure 4. Heat map for Prototype 1

TABLE I. Eye tracking data for Prototype 1.

Prototype 1	GZ		FX	
AOIS	M	SD	M	SD
Map	309.08	130.46	11.43	5.00
Legend	221.43	125.77	7.07	2.81

Prototype 1	FD (sec)		TF (sec)	
AOIS	M	SD	M	SD
Map	0.31	0.15	1.54	1.01
Legend	0.32	0.23	3.59	1.01

subjects have shifted the gaze more times on the map than to the legend.

3) Fixations and Fixation Duration in Each Region: The data collected confirm that all subjects have watched both regions. Most of subjects have focused their attention more times on the map, in particular on the highlighted district, rather than on the legend ($t(13) = 2.35$, $p = .03$). Moreover, each fixation has lasted almost the same time on the legend and on the map, ($t(13) = .08, p = .94$).

4) Time to First Fixation in Each Region: During the scanning phase, participants have started by looking at the map and then they have switched to the legend ($t(13) = 3.81, p = .002$). This is what we expected: it is a supporting evidence that the task has been performed correctly because from the legend the subjects have extracted the information to interpret the map.

5) Answers to the Questionnaire: According to the results represented in Table II, no subject has recognized the city map represented in Prototype 1 (question 1). This is reasonable since the considered sample of subjects (made by students all living far from Turin) presumably is not familiar with the Turin city map. Of the 14 people who have seen Prototype 1, only one has not been able to recognize the urban decay phenomenon described by the maps (question 2). 8 subjects have responded correctly to question 3, by then understanding when the general trend of the urban decay (incremented or decremented, according to the order the pictures have been presented). Finally, most of subjects (11 of 14) have been able to correctly determine the trend of the decay level in the highlighted district (question 4).

TABLE II. Questionnaire results for Prototype 1.

Prototype 1	Qst1	Qst2	Qst3	Qst4
Right answers	0	13	8	11
Wrong answers	14	1	6	3

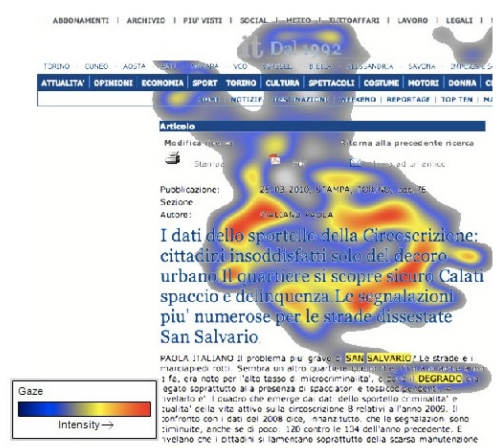

Figure 5. Heat map for Prototype 2

B. *Results for Prototype 2 (semantic support)*

1) Heat map: Figure 5 represents the heat map we have obtained from the eye tracking analysis of the testers visualizing the Prototype 2 support (Article 1). Red spots, over the info box and the title, indicate that the group of subjects have moved to these regions of interest for a significant period of time. Moreover, we can notice that the highlighted words in the text have also captured the subjects' gaze.

2) Gaze Observations in Each Region: Considering the gaze results in Table III, the majority of subjects have mainly looked the information box of the article and the title ($t(13) = .26$, $p = .79$), as it can be noticed by the comparison with the newspaper heading measurements. The text of the article has been watched by only 8 of 14 subjects, probably because of the time constraints ($F(3.39) = 18.8, p = .000$).

3) Fixations and Fixation Duration in Each Region: The data provided in Table III confirm that all subjects have watched much more the info box and the title rather than to the newspaper heading and the text ($F(3.39) = 17.6, p = .000$). The fixations have lasted almost the same time in each AOI ($F(3.39) = 2.12, p = .11$), indicating a comparable visual complexity between each AOI.

4) Time to First Fixation: As it emerges from the recordings, the subjects have adopted similar strategies to scan the image, starting from the top of the page, i.e., from the newspaper heading , to the bottom, i.e., the text of the article, passing trough the info box. The participants have ended the scanning phase on the title where they have spent most of the time in order to get information ($F(3.39) = 2.96, p = .04$).

5) Answers to the Questionnaire: As Table IV shows, only two subjects have realized that the phenomenon took place in Turin. 8 of 14 have been able to recognize the phenomenon described in the articles and have answered correctly to the

TABLE III. Eye tracking data for Prototype 2.

Prototype 2	GZ		FX	
AOIS	M	SD	M	SD
Heading	259.86	94.20	35.48	21.13
Title	245.67	116.66	83.57	40.51
Info box	118.66	67.28	89.04	37.77
Text	20.95	38.49	6.67	14.65
Prototype 2	FD (sec)		TF (sec)	
AOIS	M	SD	M	SD
Heading	0.25	0.05	2.24	1.13
Title	0.23	0.07	5.21	2.97
Info box	0.15	0.26	2.31	1.56
Text	0.29	0.12	3.01	3.86

TABLE IV. Questionnaire results for Prototype 2.

Prototype 2	Qst1	Qst2	Qst3	Qst4
Right answers	2	8	7	2
Wrong answers	12	6	7	12

question 2. The other 6 subjects have not remembered exactly what kind of issues was the article about, even if the topic was extensively described in the news and the word "decay" was highlighted in yellow. Of 14 subjects, half of the subjects have answered correctly to question about the decrease or increase of the phenomenon and the other half in the wrong way (question 3). Finally, 12 subjects have not been able to remember the name of the San Salvario district, despite of the layout emphasis it has been given within the text.

The answers reflect the effects of a natural reading approach performed by young students in 15 sec. While they known in advance they would have had only that limited time interval to observe the support, they have not been instructed to read as much as they can from the articles, nor to apply, if known by them, any strategy of rapid reading (that is, however, a quite rare skill). By relaxing the time constraints, the subjects would have had, of course, the possibility of acquiring all the needed information to answer the questions correctly. Even without considering the application of fast reading methodology, the ability of extracting information by text should be considered quite high, since university students are acquainted with the task, presumably more than other categories of subjects involved with more practical and manual activities or with a minor level of education.

C. Comparison

After the separate analysis of the behavior of the groups in relation to Prototype 1 and Prototype 2, a between-groups-analysis has been performed for comparing the heuristic strategies adopted by the participants. Newspaper heading and text of Prototype 2 have been excluded by the comparison since they have been considered only by a minority of the subjects for an irrelevant time, as it emerges by previous analysis. The times of gaze observation on the legend and district regions belonging to Prototype 1 and the ones on the info box and title regions in Prototype 2 are nearly similar ($F(1.26) = 1.56, p = 0.22$).

The frequency of fixations in the legend and district regions belonging to Prototype 1 and the one in the info box and title regions in Prototype 2 are nearly similar ($F(1.26) = 3.28, p = 0.08$). The fixation durations in the legend and district regions belonging to Prototype 1 and the ones in the info box and title regions in Prototype 2 are nearly similar ($F(1.26) = 0.156, p = 0.69$). In time constrained contexts, the totality of the subjects has adopted comparable heuristics, within the regions considered most significant.

In order to evaluate the informative power of the two supports, a comparison has been also made between the correct and the wrong answers to the questionnaires.

As the answers to question 1 show, almost all the participants have not been able to geographically contextualize the represented phenomenon, either by looking at the city map nor by scanning the text articles. This is probably due to the fact that the represented urban change involves an area which is not the one the participants live in, so they are not familiar with the cartographic representation of the city and with the local peculiar urban and social problems.

Questions 2 and 3 focus on the topic and on the trend comprehension, regardless the understanding of the involved physical area. Performances in terms of correct answers seems to show there is a better understanding of both the arguments for participants looking at the perceptual support.

Questions 4 have been designed to explore the effectiveness of the selective highlighting in the supports. Due to the diversity between the kind of the support, questions 4 are formulated differently but they both focus on the same purpose, i.e., they check for the effects of higlights: in the first case, what is highlighted in the perceptual supports is an area and the minimum effort the subject can do is observing the change in the color; in the case of the semantic supports, words are highlighted and the minimum effort the subject can do is reading them. While the eye tracking has demonstrated that the highlighted keywords in Prototype 2 have attracted the subjects' attention, almost nobody has been able to recall the name of the district interested by the urban change. The highlighted region of the map also captured the viewers' gaze, as showed by the eye tracker. Participants have focused on the changes on such area and correctly interpreted the time evolution of the phenomenon represented by the infographics.

Question 2 and 4 registered a significant difference of correct and wrong answers between Prototype 1 and 2. A chi-square test has been performed by considering the answers to questions 2 and 4. Such a test has showed that, despite the semantic information is clearly and extensively described through a textual description, synthetic perceptual information is more effective for informational purposes ($X_2(1) = 12.65$, $p = .000$).

V. Conclusion and Future Work

Cities are living systems and urban changes are complex phenomena that involve time and space. Understanding cities metamorphosis is important for citizens and administrations for several reasons: for example, to empower the weakest areas by means of the presence of public services, to keep under control the urban decay, to monitor the effects of administrations' choices in the long run, to support business decision making on the territory and to directly involve citizens in the administration policy.

The aim of this study was to test the communicative effectiveness of different data storytelling strategies in the field of urban changes. To this purpose, we have provided two groups of 14 young students each with respectively an infographic support and a textual support for a time interval of 15 sec. All the subjects have no a priori hints about the represented phenomena.

We have compared the informative power of the two strategies on the basis of eye tracking data and answers to ad-hoc designed questionnaires.

While questionnaires are a typical way to check the information processing and comprehension in real experiments, by the eye tracking we gain deeper insights with respect to the classical path between the questions and the answers.

Thanks to the eye tracker device, we have observed the fruition strategies of the subjects. We have found that they have applied a similar scanning strategy for the understanding of the infographics and of the news reports, i.e., within each support, they focus on a single area that better synthesizes the main information (the legend area for the map and the title for the article).

On the other hand, by considering the answers to the questionnaires, we have discovered that, in a time constrained situation, the subjects better understand the phenomena when they are depicted in the synthetic infographics rather than when they are extensively described by narrative texts.

These data let us conclude that, for young people with a medium-high level of education, the informative power of infographics is stronger than the newspaper articles' one in time-constrained scenarios, where the users apply a scanning strategy of the information support, rather than a careful reading.

To generalize the statement, we first need to enlarge and differentiate the sample of participants in future experiments. We can exploit such analysis in a future comparison with people having a prior knowledge about the urban problems, in order to assess how the understanding of the represented phenomena changes when the recipient of the communication strategy is already aware of (and directly touched by) the topics.

Finally, we are going to apply the presented methodology of evaluation of different data storytelling supports in more complex urban changes evolution scenarios, as well as in application domains with other communication goals.

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